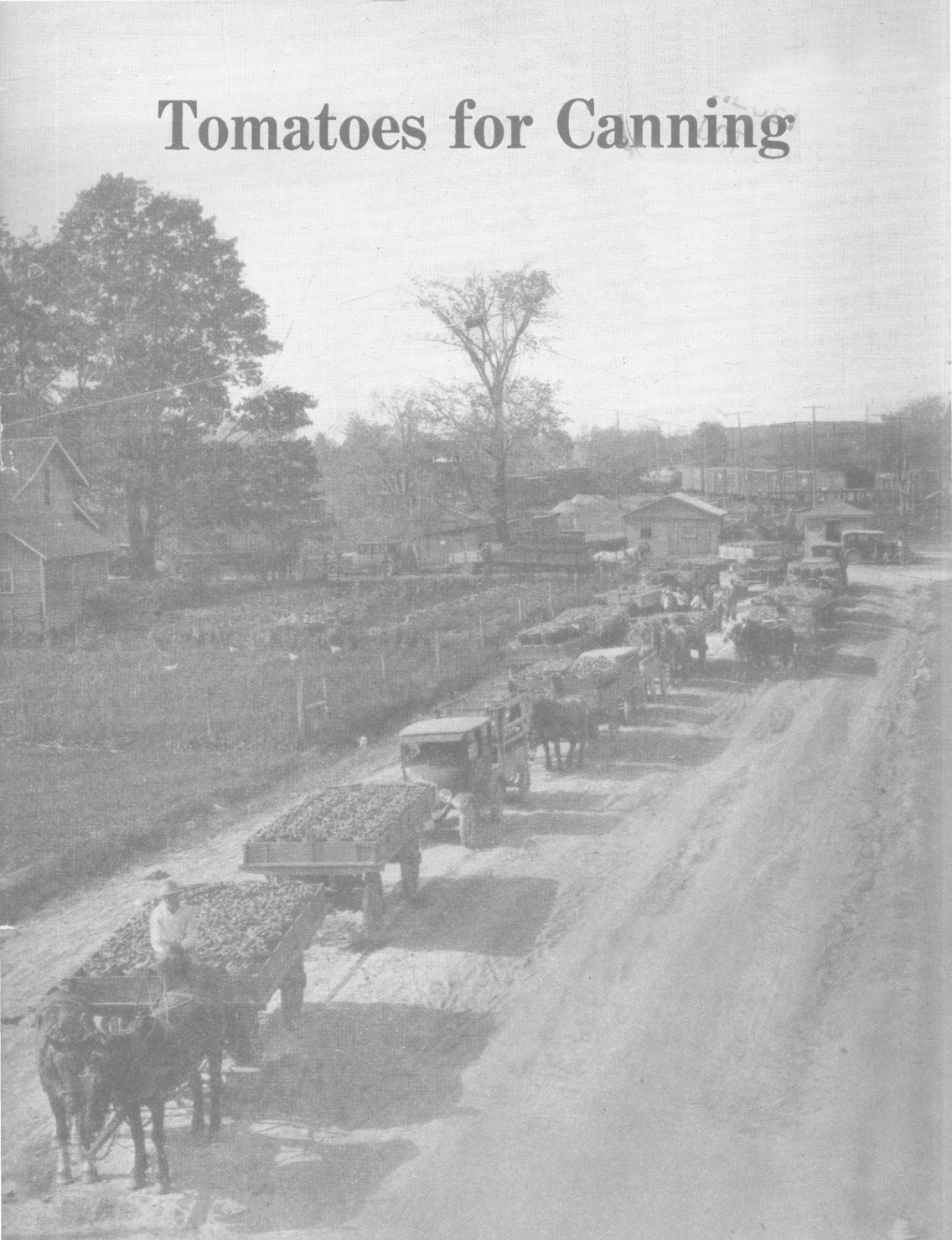
Tomatoes for Canning



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CONTENTS

GROWING THE TOMATO CROP
By E. R. Lancashire

TOMATO INSECTS AND THEIR CONTROL
T. H. Parks

TOMATO DISEASES AND THEIR CONTROL
A. L. Pierstorff

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TOMATOES FOR CANNING

By E. R. Lancashire
Extension Specialist in Vegetable Gardening, The Ohio State University.

Growing tomatoes for canning factories in Ohio is a profitable business. The average yield is seldom below 5 tons per acre. The highest yields are in excess of 20 tons per acre.

The growing of tomatoes for canning factories is becoming more important each year. The total acreage contracted has increased steadily during the last five years. The business is at present located almost entirely in the western half of the state.

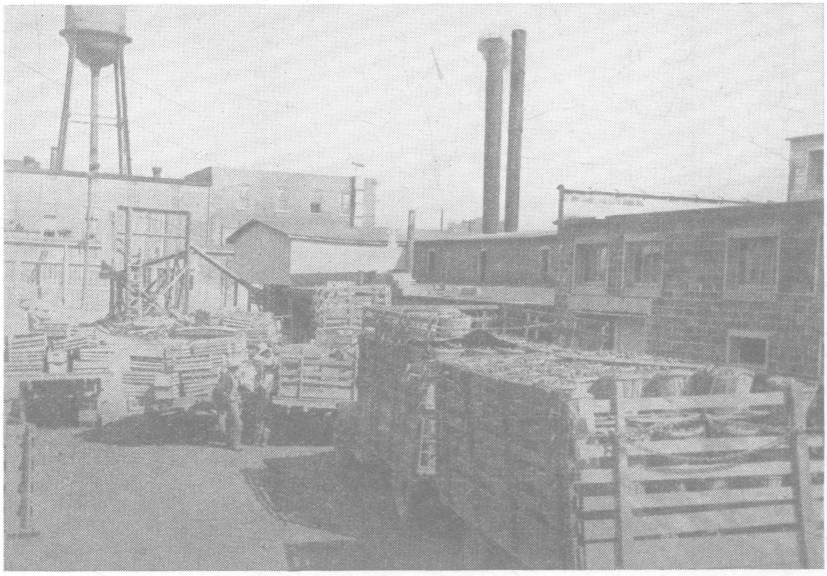


Fig. 1.—The illustration shows a modern Ohio tomato factory during a busy season. These factories offer a profitable market for the late or main tomato crop.

Several new and modern factories for the canning of tomatoes have been erected during this five-year expansion period (see Fig. 1). In some of the factory districts, the average yield was in excess of 10 tons per acre for the 1930 season.

During this same year, 230 members of Ohio's 10-Ton Tomato Club produced yields in excess of 10 tons per acre; 22 members of the 15-Ton Tomato Club, produced yields of 15 tons or more per acre; and one member made the 20-Ton Tomato Club with a yield of 21.56 tons per acre on a 2.12 acre field.

Cultural Factors

Climatic Requirements

The tomato is a perennial plant which usually lives in Ohio until killed by frosts, diseases, or insects. Tomato plants die at temperatures lower than 30°F. High temperatures are not harmful to the tomato crop if the moisture supply is sufficient.

Maximum yields are obtained when well grown plants are set in the field during the last week of May, provided the first killing frost in the fall does not occur before the second week in October. Approximately 140 days in the field are necessary for the production of a profitable yield of tomatoes for the canning factory. Such a growing season exists in nearly all sections of Ohio. The state is well adapted, climatically, to the production of tomatoes for the canning factory.

Soils

The roots of a tomato plant spread out in every direction. A single plant will cover 24 or more square feet in its search for plant nutrients and moisture. Some of the roots penetrate to a depth of 3 feet or more, depending upon the soil and the moisture supply. The bulk of the roots are in the plow layer (see Fig. 2).

Loams and silt loam soils best meet the requirements of the tomato root system under average climatic conditions. Well drained soils of heavier or lighter types can be made to produce high yields of late tomatoes, provided such soils are well supplied with organic material. Excellent yields are produced on deep, black, loam soils. Any well drained, fertile soil which will permit the rapid development of the tomato root system, and is provided with sufficient organic materials to insure a high water holding capacity, can produce a profitable tomato crop.

Rotations

A four- or five-year rotation is advisable for the tomato crop. Such a rotation permits the maintenance of the organic supply of the soil. Tomatoes should not follow tomatoes in the rotation. Lower yields are usually produced the second year because of the reduced supply of organic matter in the soil.

The following rotations are suggested:

1. Five-year rotation.—Tomatoes, corn, oats or barley, alfalfa, alfalfa.
2. Four-year rotation.—Tomatoes, corn, soybeans, oats or wheat (sweet clover)

Green Manure Crops

Any legume preceding the tomato crop is preferred to a non-legume because it builds up the organic supply of the soil faster and adds nitrogen to

the soil. Green legumes decay rapidly when they are plowed. A high fertility level is required for the growing of legume crops, and such a cash crop as the tomato is worthy of the best treatment possible.

According to present information, sweet clover is the best crop to precede tomatoes. Sweet clover adds more organic matter to the soil than any other crop. Sweet clover should be plowed during the early spring of the second year's growth. It is important to wait until every shoot of the plant has started to grow so as to permit the food stored in the roots to become ex-

Fig. 2.—The roots of a tomato plant spread out in every direction and they are very close to the surface of the soil. The tomato roots shown in the picture were exposed by washing the soil away with water. Deep cultivation destroys these roots.

hausted. Plowing sweet clover down as soon as the first growth is 6 inches high is the most satisfactory time. Practically all growth of the sweet clover is effectively checked by this system of plowing. The few plants which survive can easily be controlled with disking and cultivating.

Alfalfa and red clover also are satisfactory legumes to precede the tomato crop. After the first cutting of red clover or the second cutting of alfalfa the field should be top dressed with manure so as to increase the growth of these legumes.

Soybeans can precede tomatoes on soils which are too acid for sweet clover, alfalfa, or red clover. Soybeans are planted during May and turned under as soon as the lower pods begin to mature (see Fig. 3). As soon as the soybeans are plowed a rye cover crop should be sown, so as to prevent the loss of nitrogen during the fall and winter and to further increase the total supply of organic matter. The rye should be plowed under as soon as it reaches the first joint stage the next spring in order to completely kill the crop.

Seedbed Preparation for Tomatoes

Fall plowing usually results in bigger yields than does spring plowing. Soils which wash readily or which contain so little organic matter that they become too compact when fall plowed should be spring plowed. Spring

Fig. 3.—Turning under a green manure crop (soybeans) for tomatoes. Sweet clover, alfalfa, red clover, soybeans or some other legume should precede the tomato crop.

plowed fields should be disked before plowing as an aid to the elimination of dead air spaces in the bottom of the furrow.

Greater yields from fall plowing result chiefly from the increased supply of water stored in the soil under such management. Organic matter turned under in the fall has more time to decay than when spring plowed. The air pockets in fall plowed soil fill in as a result of freezing and thawing which takes place during the winter. Fall plowing also results in a better mechanical condition of the surface soil.

The spring preparation of the seedbed consists of the frequent use of a disk or other type of harrow. On heavy soils such as clays and silty clays the soil should be at optimum moisture content whenever worked with a disk, espe-

cially when the organic content of these soils is deficient. This will prevent packing of the under surface soil. The frequent working of the seedbed (where practical) will kill weeds and will keep the surface of the seedbed in ideal condition for the retention of moisture.

A firm, fine seedbed is necessary for the successful transplanting of tomato plants. Successful transplanting requires the reestablishing of the roots of the plants in direct contact with moist, finely divided soil. Air pockets between the roots and the soil are likely to occur when the soil is cloddy.

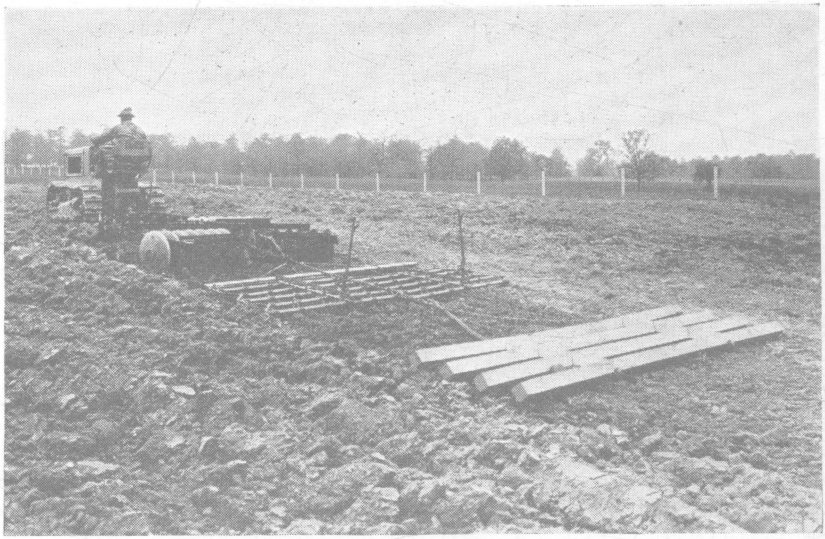


Fig. 4.—Fall plowed legume sod should be disked frequently from early spring until plant setting time. The soil should be thoroughly prepared by using a plank-float after the disc and harrow, until the surface is leveled and the small lumps pulverized.

The Use of Barnyard Manure

Since livestock is pastured during the summer, very little manure is available for fall plowed fields unless the winter manure is held over in concrete pits during the spring and early summer. Strawy manure applied to hay fields is objectionable, because some of it may be picked up by the hay rake or loader. About the only solution to this problem is that of applying manure to the green manure crop as a top dressing. Sweet clover can be top dressed with manure any time after the nurse crop is removed. Alfalfa or red clover can be manured after the last hay crop is cut. Soybeans or rye can be manured any time after they are planted.

Tomatoes respond readily to the use of fresh barnyard manure when it is applied previous to the beginning of January. The earlier manure is applied, the more decomposed it is when the tomato plants are set in the field. Only well rotted manure should be applied in late winter or early spring. When

properly used, manure increases the fertility of the soil and improves its water holding capacity. Better drainage and better aeration of the soil are also the result of plowing under manure. Ten big loads of manure per acre for the tomato crop is a profitable rate of application.

Fresh barnyard manures contain approximately 10 pounds of nitrogen, 12 pounds of potash, and 5 pounds of phosphoric acid per ton. On this account it is practical to use superphosphate to build up the supply of phosphoric acid carried by the manure to a point where the combination will equal the use of a well balanced, complete fertilizer. Seventy-five pounds of 20 per cent superphosphate applied with each ton of manure would establish a favorable balance between the nitrogen, phosphoric acid, and potash added to the soil in this program.

Commercial Fertilizers for Tomatoes

The use of commercial fertilizer pays maximum dividends only when the supply of organic material in the soil is satisfactory. When such a condition exists, the moisture capacity of the soil is usually sufficient to insure the optimum use of commercial fertilizer by the tomato crop. To obtain the full benefit of commercial fertilizer on the tomato crop, it is important to first build up the organic supply of the soil to a point where it will be able to make maximum use of such applications.

Sandy soils frequently are deficient in both nitrogen and potash. All the soils in Ohio are deficient in available phosphoric acid except those that have been used for vegetable production for several years. Light colored soils are deficient in nitrogen unless they have had liberal applications of fertilizer and manure. Heavy applications of manure increase the nitrogen and potash content of all soils. Potash is frequently deficient in dark colored loams, silts, and clay loams which are well supplied with organic matter.

A minimum of 500 pounds of a well balanced commercial fertilizer can profitably be used on each acre of soil planted with tomatoes. Applications of more than 500 pounds per acre are recommended only when the grower knows through experience that it is practical for his particular field.

Since a complete fertilizer contains available nitrogen which is readily leached from the soil, it is best to apply such a fertilizer just before setting the plants. The most economical and satisfactory way to apply the fertilizer is with a grain drill. If satisfactory tools are available, hill or row applications (200 to 400 pounds per acre) of a complete fertilizer are often a profitable supplement to the broadcast applications. Potato planters with fertilizer attachments could be used to make row applications.

Fertilizers should be drilled in three to four inches deep so that they will be fixed in the soil at a depth where tomato roots are most abundant. Phosphoric acid and potash do not move up or down in the soil as readily as nitrogen does. Phosphoric acid and potash remain very nearly where they are placed and so it is desirable to work the fertilizer well down into the soil where the roots of the plants will be able to reach it.

The recommended fertilizer on light colored silt and clay loams is a 2-14-4. When these soils have not been manured or built up with legume

crops, the additional use of 100 to 200 pounds per acre of a nitrogen carrying fertilizer such as nitrate of soda or sulfate of ammonia is practical if the vines are light in color and dwarfed in size. This is applied as a top dressing when the plants have set their first cluster of fruits. A one-row fertilizer drill can be used to put on this top dressing, or the nitrogen fertilizer can be spread broadcast by hand on the surface of the soil.

The light colored sandy loams are fertilized with a 4-12-4 when used with manure or legumes. Two hundred pounds of sulfate of ammonia or nitrate of soda should also be added as a top dressing if the vines indicate that it is necessary. Light colored, slow growing foliage indicates a shortage of available nitrogen in the soil.

Dark colored loams, silt and clay loams respond to an 0-14-6 or 0-12-12 fertilizer. The 0-12-12 gives good results on black soils. If the top growth is not dark enough in color and if the vines are growing slowly, a nitrogen top dressing should be added.

Such recommendations as are made here are only for the purpose of establishing a working basis. Each grower would do well to test out fertilizers until he has one which suits his soil and crop rotation system best.

A grower can usually tell when a tomato plant needs additional nitrogen. If the plants are small in comparison with other plants of the same age or if the foliage is a yellowish green in color it is more than likely that the supply of nitrogen is nearly exhausted. The plant which is starving for nitrogen sets very few and very small fruits.

Tomato plants growing on soils which are deficient in acid phosphate are dwarfed in size. The foliage is a very dark green color. Acid phosphate starvation symptoms are not as well known as are those for nitrogen. Since practically all Ohio soils are deficient in acid phosphate this information will be of interest to tomato growers.

Potash starvation symptoms have been worked out for several vegetable crops, including tomatoes. Tomato plants which are showing potash deficiency symptoms are of normal size. The most important way of identifying such plants is to examine the lower leaves. If very small spots appear along the veins and these later become so numerous as to cause the leaves to fall off the grower may be fairly sure that lack of potash was the cause. These spots should not be confused with those of leaf spot diseases.

Lime Requirements for the Tomato Crop

The tomato crop will do well on a soil which has a *p*H value of 5.25 or higher. It is usually unnecessary to add lime for the benefit of the tomato crop except on extremely acid soils whose *p*H value is less than 5.25. The lime requirement of the legumes in the rotation will therefore govern its use. To grow sweet clover or alfalfa requires a minimum *p*H value of about 6.50, with the optimum near *p*H 7.50. For red clover the *p*H should be at least 5.50, with the optimum *p*H between 6.00 and 6.50. Soybeans will do well on soil with a *p*H of 5.25 or higher. If fertilizer and lime are applied at the same time, they are likely to combine chemically, with a loss of availability and efficiency.

Tomato Varieties for Ohio

Fig. 5.—United States Number 1 canning tomatoes. The variety shown is the Baltimore.

The two varieties most used for the tomato canning factory crop are the Baltimore and Marglobe. The Baltimore gives satisfactory returns provided the soil is not infested with Fusarium wilt of tomatoes. Where such a condition exists, the Marglobe variety should be used. It is about 95 per cent resistant to Fusarium wilt. Both the Marglobe and the Baltimore are excellent canning tomatoes.

In a three-year variety test the Marglobe and Indiana strain of Baltimore yielded at the rate of 7 tons or more per acre. The Stone and Norton varieties of tomatoes produced only a little more than 6 tons per acre. Bloomsdale and Landreth are frequently used for canning purposes.

One of the difficulties confronting the grower and canner of tomatoes is that of distributing the peak load of the picking season over a longer period of time. This cannot profitably be done by making a succession of plantings of tomatoes, because such a practice results in reducing the yield per acre. The use of more than one variety in the field, provided each variety was planted in a separate section, would aid in distributing this peak of production. Bloomsdale and Baltimore would be a good combination, since Bloomsdale requires several days less time to mature a crop than the Baltimore does.

Seed Sources

There is often as much difference between seed strains of the Baltimore variety of tomato as there is between the Baltimore variety and any other variety. On this account it is very important to obtain a superior strain of seed of the particular variety desired. There is nothing to be gained by buying inferior seeds. Only a reliable seedsman should be depended upon as a source of tomato seeds.

Plant Sources

Tomato plants can be obtained from southern plant growers; they can be produced locally in community plant beds operated by the canning factory or by the growers; they can also be grown on the farm where they are to be used. The last of the three sources of plants is to be preferred (provided the plants are grown properly). The plants so produced can be set in the tomato field without taking the risk of using woody plants, plants that are too small, plants that are too large, or plants that contain a variety mixture.

Only when the plants are produced on the farm where they are to be used can the grower be absolutely sure that he is getting the kind of plants which produce maximum returns per acre. Plant growing, however, requires considerable skill. A little neglect, either through lack of knowledge or carelessness, is almost sure to produce inferior plants.

Plant Growing

Starting the Seed.—A composted soil or a sandy soil is preferred for plant growing because of the ease with which it permits the root system to develop. If such a soil is placed in a shallow, wooden tray having dimensions of 2½ by 12 by 18 inches, it (see Fig. 6), it is possible to germinate 500 tomato seeds in it. Six to eight seeds per inch of row, with the rows 3 inches apart, are planted in this tray. The depth recommended for seed sowing is ¼ inch. Sowing the seed in rows makes it easy to lift the plants when they are ready for transplanting to the coldframe. If steam is available it is advisable to steam the soil for one hour before planting the seed.

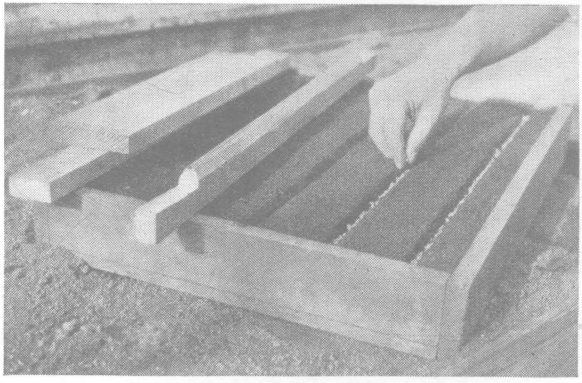


Fig. 6.—Sowing tomato seeds in a 2½- by 12- by 18-inch wooden tray. The seeds are planted in rows 3 inches apart with 6 to 8 seeds per inch of row.

Such a system also makes it easy to cultivate between the rows of plants and to speed up the drying out of the surface soil after the plants have been watered. These flats should be kept in a glass covered hotbed, the temperature of which can be held at 60°F. at night and 70°F. in the daytime. When the temperature rises above these points, the glass sash covers of the hotbed should be gradually raised. Sudden temperature changes are not desirable.

It takes six to eight weeks from seeding time to plant setting time to grow a tomato plant. Such a plant should be five to seven inches high, stalky, and with the blossom buds forming. Taller plants, with blossoms open, frequently

drop their flowers when the plants are set in the field. This loss of flowers and even small fruits which have already been formed is due to the checking of the growth when the plants are removed from the coldframe and set in the field.

Moving Seedlings to Coldframe.—As soon as the seedlings in the flats have two or three true leaves well formed, they are ready for moving to the coldframe. Each seedling plant should be placed in the coldframe in rows 2 inches apart and with 2 inches between plants in the row. They remain in the coldframe until they are removed to the field. The coldframe should have either a glass or a muslin cover; other kinds of covers have been found unsatisfactory. An attempt should be made to keep the temperature of the coldframe between 60° and 70°F. Tomato plants which are grown at these

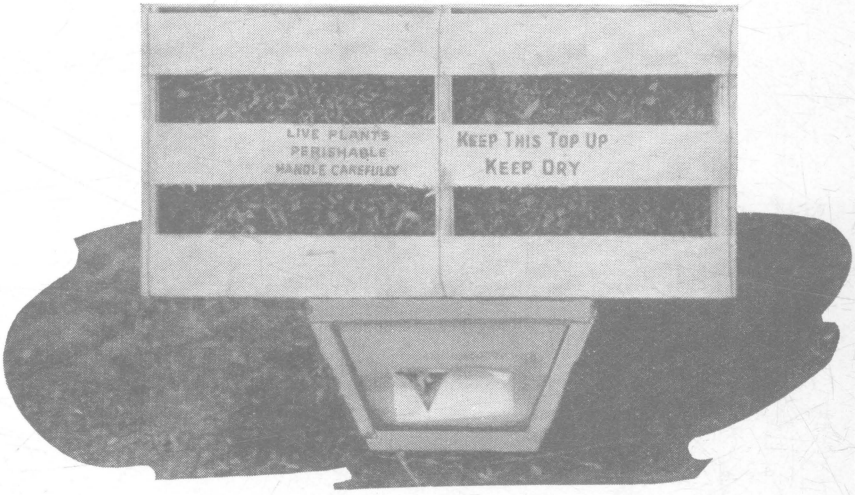


Fig. 7.—Millions of southern grown plants like these are shipped into Ohio each year. The only sure way to know just what kind of plants will be used is to grow them correctly at home.

temperatures and which have not been checked in their rate of growth will make the best plants to set in the field. The success or failure of the tomato crop is often directly traceable to the kind of plants which were used. It is important to keep the foliage of tomato plants growing in hotbeds and coldframes as dry as possible.

Hotbeds for Holding the Trays.—A tomato grower who has a 4-acre contract could build a two-sash hotbed which would accommodate twenty-four of the 12- by 18-inch trays. In these trays he could grow 12,000 tomato seedlings. When transplanting time arrived, it would be necessary to provide a coldframe 6 feet wide and 60 feet long, to accommodate the 12,000 tomato seedlings, which are to be spaced 2 inches apart each way.

The cost of this equipment would be returned to the grower in the saving he would make in one or two years by growing his own plants in place of

Figs. 8 and 9.—Temporary hotbeds and coldframes used in Pickaway County, Ohio.

buying them from someone else. The satisfaction of having these home grown plants available in the right condition and at the right time for setting in the field, would be ample return for the time invested in the growing of these plants. Complete directions for growing of tomato plants and for the construction of hotbeds and coldframes are given in Ohio State University Extension bulletin, No. 103.

Spring Seeding in Field.—Many canners sow seed in the field about April 1 to 15 at the rate of five to six pounds per acre, in order to produce a crop of late plants which are used for replants, and to insure against failure in case the hotbed plants or plants from other sources are not available as expected. Seed for these late plants is sown on rich soil by means of small, hand seed drills.

Condition of Plants

Whether the grower obtains his plants from someone else or whether he produces them on his own farm, they should be in good condition when they are set in the field. To be in good condition, a plant should not be wilted, diseased, or woody, and it should be about the thickness of a lead pencil, branched, 5 to 7 inches high, and have a blossom cluster just forming.

Southern grown plants are shipped in well ventilated boxes. The roots of these plants are packed in moist material and the tops are kept dry. These plants frequently arrive in a wilted condition and should be immediately removed from the container and "heeled in." This can best be done by laying the plants in a trench and covering the roots with moist soil. The plants should be separated as much as possible in this "heeling in" process. As soon as the plants have made new roots and have regained a normal, unwilted condition, they are ready for transplanting to the field. The foliage of southern grown plants should never be watered in the original containers.

Setting Tomato Plants

Date of Setting.—Setting tomato plants in the field as soon as the last killing frost in the spring is over will result in the largest possible yields. The last part of May is usually the safest time to set tomato plants in the field in northern Ohio. Plants could be set out a few days earlier in the southern part of the state. The date of setting tomato plants has a direct bearing upon the total yield. (Fig. 10 shows average dates of last killing frosts.)

A survey of tomato growing methods in Ohio shows that tomatoes set during the last half of May have a far greater chance of producing yields of 10 tons or more per acre than plants set during the first or second week in June. In a few instances, tomato plants set in the field as late as the middle of June have been known to produce yields of 10 tons or more per acre, but usually such instances are recorded in years when the harvesting season is continued until the second or third week in October.

Method of Setting.—The machine method of setting tomato plants is better than the hand method in case the soil is dry. If the soil is moist, setting

plants in the field can be done satisfactorily by hand. Transplanting machines with a driver and two plant setters can satisfactorily plant 5 acres in one day (see Fig. 11). A man and a boy working together could set one acre in a day by hand.

The tomato setting machine is equipped with a water valve which liberates a half pint of water each time the valve opens. It is important that the plant setters place the roots of the tomato plant at the point where this water is released. The fact that the roots of the tomato plants are firmly pressed into

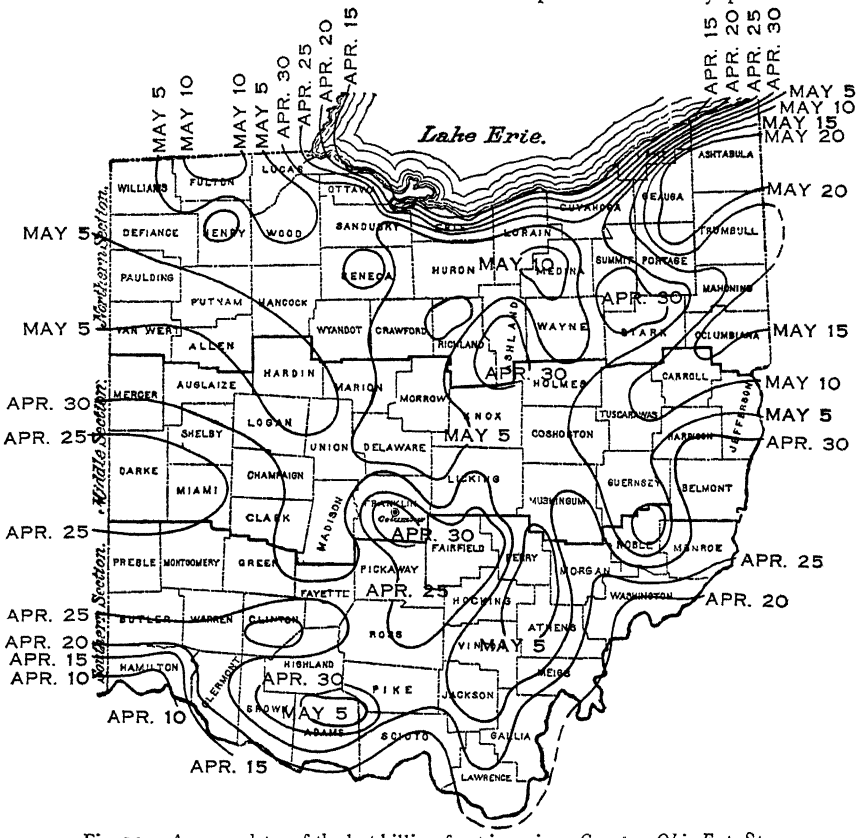


Fig. 10.—Average dates of the last killing frost in spring. *Courtesy Ohio Exp. Sta.*

contact with moist soil is the reason why a transplanting machine is better than the hand setting method when the soil is dry. Check row transplanting machines would be a still greater improvement over the hand setting method, because the plants could then be cultivated both ways with horse drawn tools. Cross cultivation is necessary unless the hand hoe is used in the row.

Tomato plants should be carefully handled from the time they are removed from the coldframe until they are placed in the soil either by the machine or by the hand method. Careful handling requires that the roots of these plants be protected from the drying influences of the sun and wind.

In pulling the plants, it is important to first water the soil around the roots thoroughly so that they can be removed from the soil with as little root pruning as possible. Under no condition is it advisable to prune the tops of the tomato plants, and the same rule might well be applied to the root system if it were possible.

Distance of Setting.—Tomato plants in fertile, well drained soil should be set 4 feet apart each way. This allows 16 square feet to each plant set. If the distance between the rows is greater or less than 4 feet, the distance between plants in the row should be changed to allow each plant a total of 16 square feet of surface area. Such a planting distance requires 2,722 plants for each acre. If the final stand is 2,500 plants, and each plant produces 8 pounds of fruit, the total would be 10 tons per acre. It would seem that 8 pounds per plant would be a goal within the reach of any good farmer.

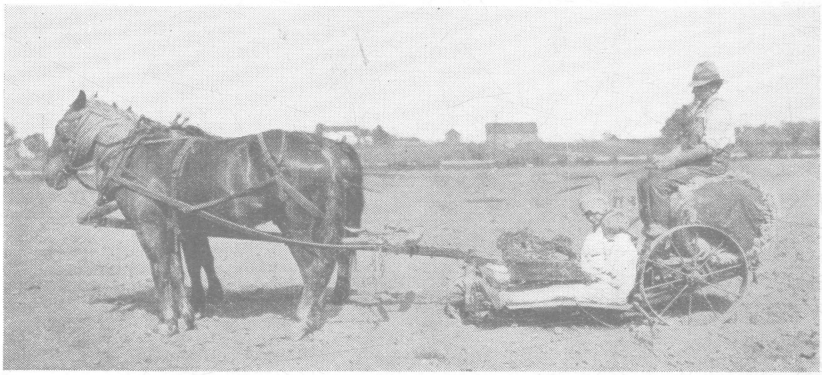


Fig. 11.—A transplanting machine with driver and two setters can satisfactorily plant 5 acres in one day.

Cultivation of Tomatoes

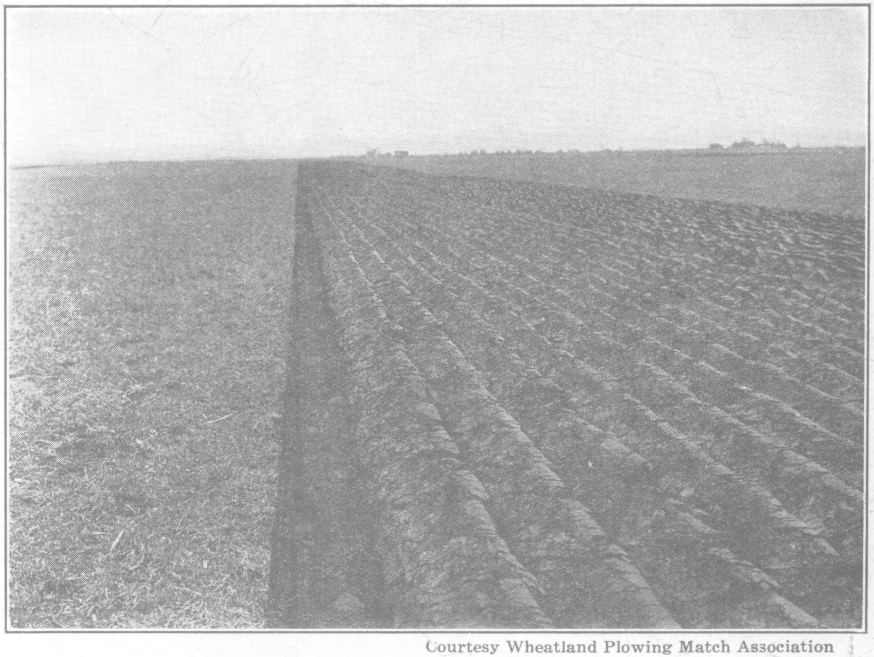
Where to Cultivate.—The seedbed preparation for the tomato crop should be so thorough that very little cultivation will be required after the plants are set. The root system of the tomato plant grows very rapidly and usually at the rate of an inch or more per day. The roots grow almost parellel to the surface of the soil and many are only one to two inches from the surface. Most of the feeding roots of the tomato plant lie between the 2-inch and the 8-inch levels of the soil. Cultivation can be deep and fairly close to the plants, provided such cultivation is given immediately after the plants are set. All later tillage should be very shallow, and should be confined to the upper one or two inches of the surface soil.

How to Cultivate.—A corn cultivator with regular shovels attached can be used for the first cultivation of the tomato field. All other cultivations are

Figs. 12 and 13.—Permanent plant growing equipment used in Wood County, Ohio. Tomatoes are started in the modern greenhouse and all plants are handled in wooden trays. Each plant is spaced 2 by 2 inches.

performed most efficiently by replacing the regular shovels with a wider type of shovel. "Sweeps" or "duck-foot" types are recommended because they are very efficient weed killers and destroy very few feeding roots of the tomato plants. Frequent, shallow, level cultivations of the tomato field should be given until there is evidence that such cultivations are injuring the foliage of the tomato plants.

The use of cultivators in a tomato field should be discontinued whenever there is danger of damaging the plants. There are two reasons for this: (1) that the destruction of foliage reduces the total leaf area, which in turn



Courtesy Wheatland Plowing Match Association

Fig. 14.—Thorough cultivation begins with good plowing.

reduces the food manufacturing capacity of the plant; the result is a lower yield per acre; (2) that any cultivation which tears the foliage aids in spreading virus diseases, such as Mosaic.

What Cultivation Does.—There are three reasons for cultivating: (1) to kill weeds; (2) to cover soil cracks; and (3) to break up a crust which may have formed on the surface of the soil. If the upper inch or two of the soil is cultivated frequently with the "duck-foot" or "sweep" type of cultivator, the soil can be kept free from weeds, and such a practice will result in the maximum retention of moisture supply. A deep mulch is not necessary in a tomato field. Cultivation of the soil below the 2-inch level is likely to result in root pruning.

Picking, Hauling, and Grading Tomatoes

Picking Tomatoes

A tomato gains in weight until it is red ripe. A tomato is red ripe when the jelly-like pulp surrounding the seeds is red. At the beginning of the harvesting season, several tomatoes should be cut open and examined carefully to see if this jelly-like pulp has changed from a greenish-yellow to a red color. With the completion of this test, the grower will be familiar with the outward appearance of a red ripe tomato. Once the tomato fruit is red ripe, it should

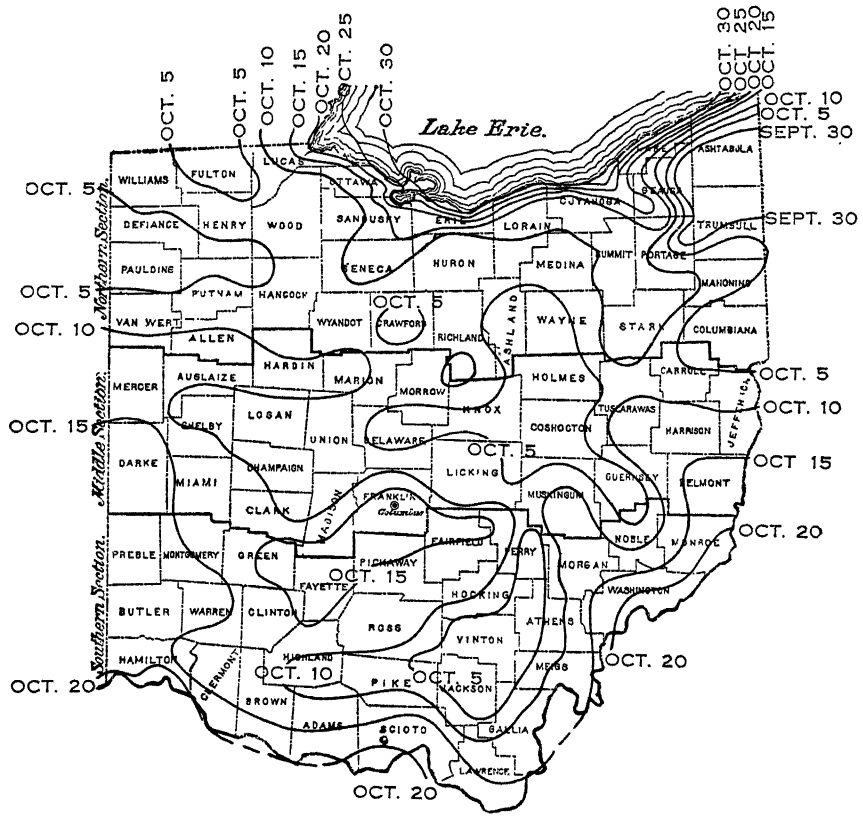


Fig. 15.—Average dates of the first killing frost in autumn (Alexander, 1). *Courtesy Ohio Experiment Station.*

be removed from the tomato vine and delivered to the factory with as little delay as possible.

Once tomatoes are removed from the vine, they begin to lose weight. The higher the temperature and the more fruits are cracked, the greater this loss will be. In picking the tomatoes, there is a natural tendency to remove from the vines fruits which are only partly ripened. Such a practice is expensive because it reduces the yield and quality of the fruit. Both the grower and the canner are penalized where such harvesting methods are employed.

Hauling Tomatoes

The handling of red ripe tomatoes from the field to the factory can be as careful as possible, yet still result in some bruising and loss of weight. Careless handling exacts a much heavier toll. Smooth roads and short hauls permit the satisfactory use of wagons. Longer hauls and rough roads make it necessary to use the automobile truck or trailer. In either case care will help to save the harvested crop until it is delivered at the factory.

Grading Tomatoes

U. S. Standards for Cannery Tomatoes (1926).—Grades for canning tomatoes which will provide a definite basis for contracts between the canner and the grower are meeting with increasing favor. Such grades must recognize variations in commercial value and still be simple enough to be practical in actual operation.

In recommending the grades given below, the U. S. Department of Agriculture has attempted to formulate the views of leading representatives of both growers and canners, and careful studies of present practices show them to be practical. However, as the idea of grading tomatoes for cannery purposes is new, a further word of explanation seems desirable.

It should be understood at the outset that the only grading required of the grower is the removal of culls. Such tomatoes should be left in the field. It is not intended that the grower sort the tomatoes into No. 1 and No. 2 grades. The proposed grades provide a basis for sampling the tomatoes as they are delivered to the cannery.

The application of these grades requires the services of private or official inspectors to determine the amounts of each grade in the various loads of tomatoes. Such inspectors must be capable, efficient, and above all they must be absolutely neutral. The inspectors' reports should show the percentages of U. S. No. 1, U. S. No. 2, and Cull tomatoes.

Buying and selling on grade will encourage better production and better handling. The present practice of paying a flat price for everything which is accepted, discriminates against the best growers. The grower should be paid a suitable premium for stock of high quality which will make a high quality manufactured product. Such stock can be canned at a minimum cost. On the other hand, there should be suitable penalties for the delivery of culls.

U. S. No. 1 shall consist of tomatoes which are firm, ripe, well colored, well formed; free from molds and decay, and from damage caused by growth cracks, worm holes, catfaces, sunscald, freezing injury, or mechanical or other means. (See Minimum Size.)

U. S. No. 2 shall consist of tomatoes which do not meet the requirements of the foregoing grade but which are ripe and fairly well colored, and which are free from serious damage from any cause. (See Minimum Size.)

Culls are tomatoes which do not meet the requirements of either of the foregoing grades.

Minimum Size.—The minimum size may be fixed by agreement between buyer and seller. Tomatoes below this specified minimum size shall be classed as Culls.

Definitions of Terms. "Firm" means that tomato is not soft, puffy, shriveled, or water soaked. "Well colored" means that tomato shows at least 90 per cent good red color. "Fairly well colored" means that tomato shows at least two-thirds good red color. "Well formed" means that tomato shall not be extremely flat or otherwise badly misshapen. "Damage" means any injury which cannot be removed in the ordinary process of trimming and peeling without a loss of more than 10 per cent (by weight) in excess of that which would occur if the tomato were perfect. "Serious damage" means any injury which cannot be removed in the ordinary process of trimming and peeling without a loss of more than 20 per cent (by weight) in excess of that which would occur if the tomato were perfect.

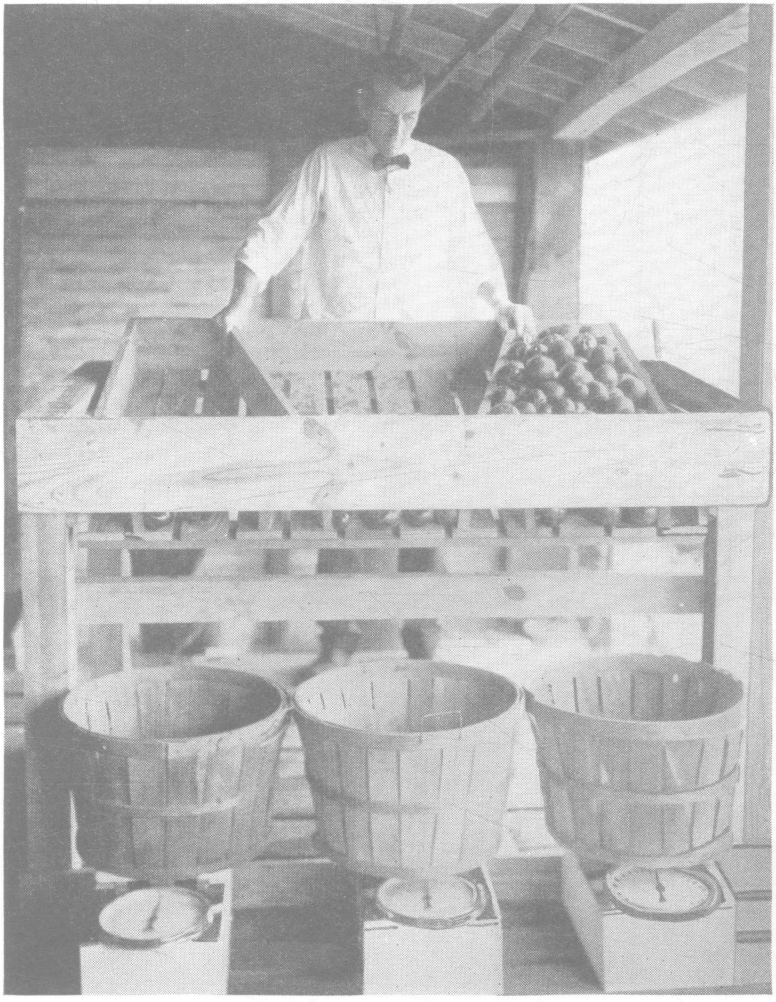


Fig. 16.—A federal inspector grading canning factory tomatoes in Ohio. Three grades are recognized: U. S. No. 1, U. S. No. 2, and Culls.

Tomato Insects and Their Control

By T. H. Parks
Extension Entomologist, The Ohio State University

Commercial plantings of tomatoes are not subject to attack by many species of insects. Those which at times are troublesome are here listed in the order of their importance:

Flea beetles	Plant lice (Aphids)
Cutworms	Corn ear worms
White grubs	Tomato hornworms
Wireworms	Stalk borers

Flea beetles are the most frequently appearing and persistent insect pests of commercial plantings. They attack the little plants in the seedbed as well as in the field. The presence of cutworms, white grubs, and wireworms depends upon the crop rotation followed and the time of plowing the ground to be used for tomatoes. The other insects named are at times injurious, but do not require a yearly control treatment to protect the plants.

Flea Beetles

These are very small, black or striped jumping beetles, which eat numerous small holes in the leaves. They feed during the entire season, but most damage is done to the little plants in the seedbed or while the plants are becoming established after transplanting. Foliage fed upon by flea beetles is unable to make a normal growth (see Fig. 17). The larvae of these beetles feed upon roots of weeds.

Flea beetles are controlled by keeping the tomato foliage covered with spray or dust as recommended under dusting and spraying (page 31).

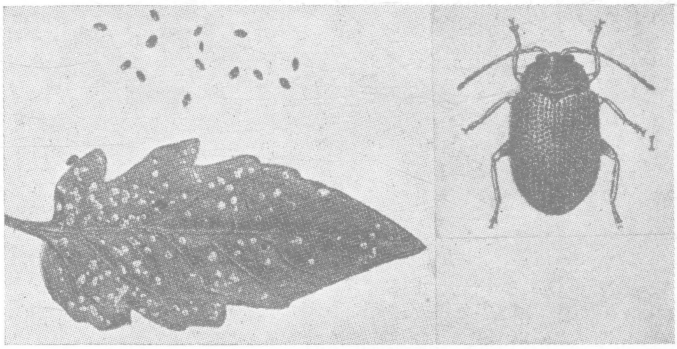


Fig. 17.—Tomato flea-beetle. Right, adult greatly enlarged. Upper left, beetles, natural size. Leaf shows injury done.

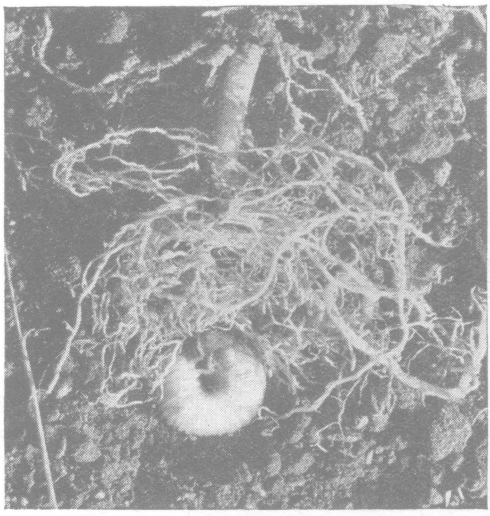


Fig. 18.—White grubs feed underground, destroying the fibrous roots of the plants.

Injury from each of these ground inhabiting species is traceable to a previous crop which has built up a population of the insects in sufficient numbers to damage tomatoes. Bluegrass or timothy sod of more than one year's standing should not be plowed under in the spring for tomatoes. Such land is likely to be well populated with one or all of these three insects (see Fig. 18).

If it is necessary to plow under such sod for tomatoes, plowing should be done in the fall, which will guarantee freedom from cutworm injury and will lessen the damage likely to come from grubs and wireworms.

If cutworms are noticed in preparing the soil for the tomato plant bed, or in the field where they are to be transplanted, these can be killed by scattering a poisoned bran mash broadcast over the soil. This mixture is made up as follows:

Bran	25 pounds
Paris green or white arsenic (not arsenate of lead)	1 pound
Cheap molasses (preferably stock feeding grade or strong smelling)	2 quarts
Water	3 to 3½ gals.

Mix bran and Paris green thoroughly. In a separate receptacle mix the molasses with the poisoned bran. The mash should be neither sloppy nor too dry, but well moistened so as to scatter thinly when broadcast. It should be applied in the evening, since cutworms feed at night. It is very effective in preventing cutworm damage in the seedbeds. If the cutworms are abundant in the field the bait should be broadcast at the rate of 10 to 12 pounds per acre before transplanting.

PLANT LICE (APHIDS)

During one season out of possibly eight or ten, plant lice may become abundant on commercial tomato plantings. The insects can be seen on the undersides of the leaves, on the blossom stems and growing tips. There are usually both pink and green forms of the insect present. They suck the sap, causing the leaves to wilt and the blossoms to drop.

Winged plant lice enter tomato fields with the wind and after becoming established, give birth to several young each day or about 50 in two weeks. These become full grown in about twelve days and in turn produce new colonies of young lice. When the weather conditions are suitable, outbreaks of this insect may develop in a surprisingly short time.

Control.—The control of plant lice requires a spray equipment capable of delivering a spray under high pressure and a boom which will deliver the spray to the undersides of the leaves. In the absence of a boom, hand work may be employed to direct the spray upward, but this is rather tedious to attempt on commercial plantings. One of the modern potato sprayers is best suited for controlling this aphid, which is better known in Ohio as the pink and green potato aphid.

The material to use is nicotine sulfate, 1½ pints to 100 gallons of water. To this is added 6 pounds of fish oil soap or dissolved laundry soap as a sticker. The soap should be dissolved in hot water and added to the mixture while being agitated. The spray must strike the bodies of the insects in order to kill them.

A saving in the amount of nicotine sulfate required can be made if an activator is used. This is a material which, when added to the dilute spray, increases the penetrative power of the nicotine and eliminates the need for soap. One such material is now on the market.

Tomato Fruit Worm
(Corn Ear-worm)

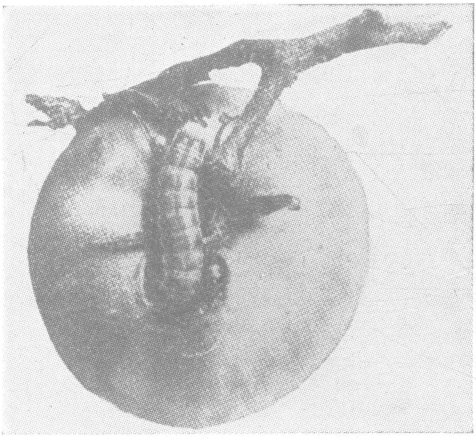


Fig. 19.—The tomato fruit worm which eats into the developing fruit is the same insect known to many as the corn ear worm. (From Quaintance and Bruss, U.S.D.A.)

Tomato fruits are sometimes injured by a large green caterpillar. The worm makes a round hole in the side of the fruit where it eats out a cavity under the skin (see Fig. 19). This is soon followed by rot, and the injury appears about the time the tomato becomes partially colored. The worm is the common corn ear-worm, and tomato fruits upon which it feeds are worthless for market. Fortunately it is not a serious pest of canning crop tomatoes but is a pest of early market tomatoes in the Ohio River Valley.

Control.—Spraying the tomatoes with arsenate of lead to cover the foliage and green fruits has been found effective in Tennessee.

Fig. 20.—Tomato worm covered with cocoons of parasites. The worm soon dies after this stage is reached.

Tomato Hornworms

These large green larvae (Figs. 20-21) are too well known to need description. They are the young of hawk moths. The eggs are laid by the moths upon tomato leaves and the worms so nearly match the color of the foliage that they are difficult to see.

Control.—This insect is usually controlled by parasites. The parasitic larvae feed within the body of the worm, then emerge and spin cocoons. Hornworms bearing these white oval cocoons on their backs have been fed upon by parasites and will not develop into parent moths (see Fig. 20).

If artificial control is necessary, dusting the plants with one part of arsenate of lead to five parts of hydrated lime by weight will be found effective.

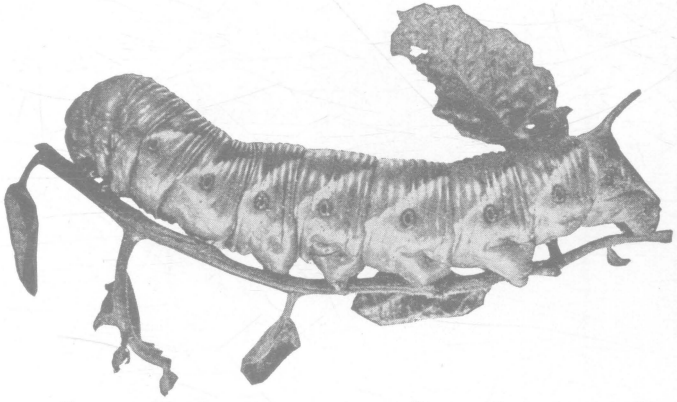


Fig. 21.—The horned tomato-worm will eat all the leaves off a plant in a few days unless the plant is sprayed.

Stalk Borers.

This is a slender striped caterpillar which burrows through the stem, causing the plant to wilt and die. Infested plants are usually found near the borders of fields and the caterpillars hatch from eggs laid in grassy and weedy areas. The borers migrate to the tomato stalks after feeding in stems of nearby bluegrass, timothy or other grasses.

There is no direct control measure known, but injury can be prevented by cleaning up fence rows and adjoining land so that these borers are not able to get a start in the early spring in such places. Stalk borers and hornworms are more likely to be pests of home plantings where a few plants are concentrated in a small area.

Tomato Diseases and Their Control

By A. L. Pierstorff
Extension Plant Pathologist, The Ohio State University.

Tomatoes are subject to a variety of diseases which the grower must control if he wishes to secure high yields consistently. Diseases annually cost the farmers in Ohio many thousands of dollars. It is estimated that one disease alone, namely, Septoria leaf spot, causes an annual loss of 250,000 tons of tomatoes in the United States.

Septoria Leaf Spot

Caused by *Septoria lycopersici* Speg.

Septoria leaf spot, or late blight, as it is sometimes called by the growers, may attack the plants from the time they are in the seedbed until after harvest. Small circular spots are first noticed as water-soaked areas on the under surface of the older leaves. Infection may also take place on the upper

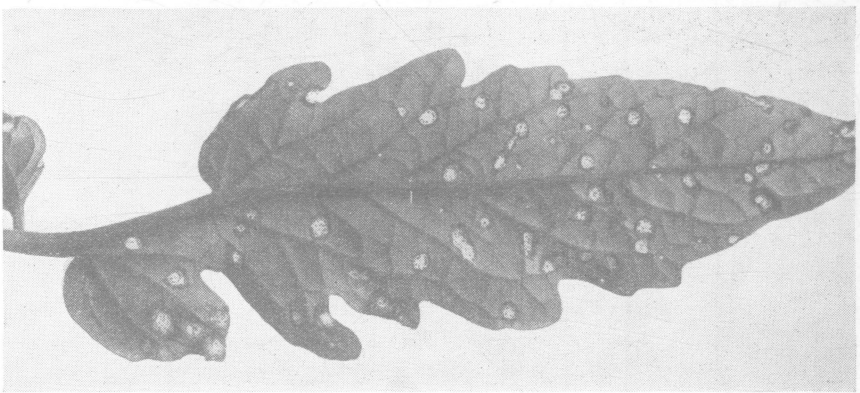


Fig. 22.—Septoria leaf spot on tomato foliage. (After Gardner.)

surface of the leaf. The fungus quickly kills the leaf tissue, causing small spots with dark brown margins and grayish sunken centers to appear on both surfaces of the leaf (see Fig. 22). The spots become so numerous that the leaf turns yellow, dries up, and clings to the plant or is blown away.

During each rain the spores of the fungus are spread to newly formed leaves; sometimes at the beginning of harvest the only green leaves left on the plant are the uppermost ones. This permits the sun to shine directly on the tomato fruits, causing an increase of *yellow-end* and *cracked* tomatoes. Also, by depriving the plant of its leaves, food necessary to ripen the fruit is lacking and an inferior tomato is produced. The fungus which causes this disease lives over the winter on old tomato refuse and the refuse of some weeds, like horse nettle, jimson weed, and ground cherry.

Control.—Since the canning factories furnish plants to most growers, only disease free plants should be sent to the growers. The first essential step in controlling Septoria leaf spot of tomatoes is to set out clean, healthy plants in soil which has not grown tomatoes for *at least four years*. The vines from the previous crop of tomatoes, even though in adjoining fields, should be covered up by plowing before the new plants are set out. The plants should be dusted in the seedbed every week or ten days after the first true leaves are formed (see spraying and dusting, page 31). As far as practicable, horse nettle, jimson weed, and ground cherry should be eradicated from the tomato field and not permitted to grow near the plant bed.

Fusarium Wilt

Caused by *Fusarium lycopersici* Sacc.

Fusarium wilt is one of the oldest known diseases of tomatoes. It has been necessary several times in certain regions in the United States to discontinue tomato growing because of the ravages of this disease. The fungus causing it is a soil inhabiting plant, and lives for many years in the soil. Seedlings may be infected any time after germination.

It will be noticed first in the fields about blossoming time, when there will be a yellowing of the older leaves, which gradually includes more of the foliage. The older leaves dry up and the new leaves wilt during the daytime, but may recover during the night for several days. Eventually the entire plant wilts and dies.

Control.—There is only one control known for this disease—that is, to grow disease resistant plants. Where growers are troubled with wilt, they should ask their canner to supply them with wilt resistant varieties, such as Marglobe, Marvel, Norton, or other more recently selected strains.

Macrosporium Blight or Early Blight

Caused by *Macrosporium* spp.

The fungus which causes Macrosporium or early blight on tomatoes, is identical with the one which causes early blight on potatoes. The spots on the leaf are dark brown, circular or oval in shape, and are marked with

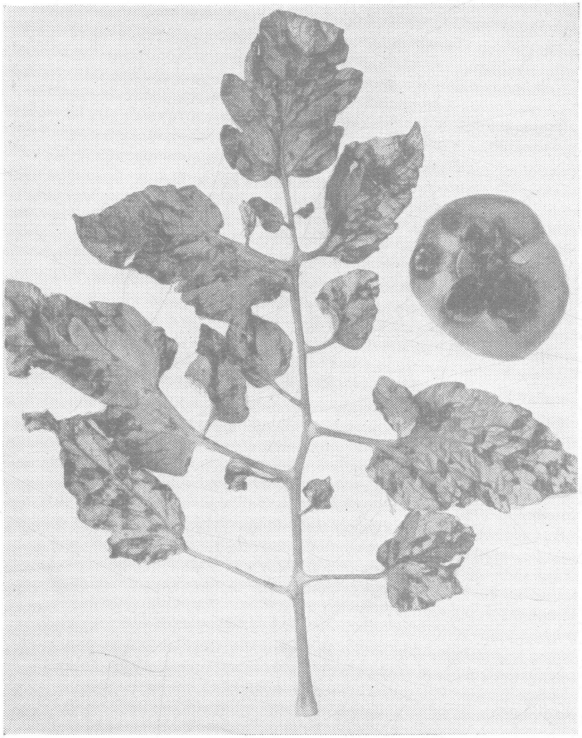


Fig. 23.—Early blight on leaf and fruit of tomato. (Macrosporium).

concentric rings (see Fig. 23.) The lesions are most likely to occur first on the older shaded leaves, and may reach ½ inch in diameter. On the fruit the spots are circular, sunken areas, which are at first brown and later black, due to the spores formed by the fungus.

Sometimes the lesions take on the appearance of a "nail head," and this disease is known as "nail head rust" in the south. At other times the spots continue to enlarge until half of the fruit is infected, as shown in the illustration.

Both the spots on the leaves and on the fruit may be found at any time during the life of the plant.

Control.—The control measures outlined for Septoria leaf spot will also control early blight.

Damping Off of Seedlings

Caused by various fungi

Frequently just after tomato plants come through the ground they rot off at the surface of the soil. This damping off can be largely prevented if the water, temperature, and ventilation are properly regulated.

Control.—Methods used to control damping off are as follows:

(1) Sow the seed in soil which has been heated to 140 degrees Fahrenheit with steam for at least one hour.

(2) Sow the seed in rows with not more than 12 seeds per linear inch.

(3) Water the seedlings *thoroughly* and not oftener than necessary. It is usually not necessary to water more than once every four or five days. Watering should be done on the morning of a bright day and in the afternoon the ground should be stirred between the rows of plants with a small hand culti-

vator, which can be easily constructed by driving a nail in the end of a broom handle and bending it over.

(4) Give the plants as much air as possible.

Recent tests in New York have shown that soaking the seed for one hour in a 5 per cent solution of copper sulfate just prior to sowing aids materially in control of damping off. This merits a trial among Ohio growers.

Soil sterilizing compounds have not proved effective after the plants have come up.

Bacterial Spot of Tomatoes

Caused by *Bacterium vesicatorium* Doidge

Throughout the tomato canning areas in Indiana and to a lesser extent in Ohio, outbreaks of tomato bacterial spot have occurred during wet seasons. The disease may be noticed on the leaves as small black specks, which are likely to be angular in outline. These spots glisten and have a greasy appearance, and can be distinguished from Septoria spot by this characteristic. The center soon dries out, becomes brittle, and is likely to crack.

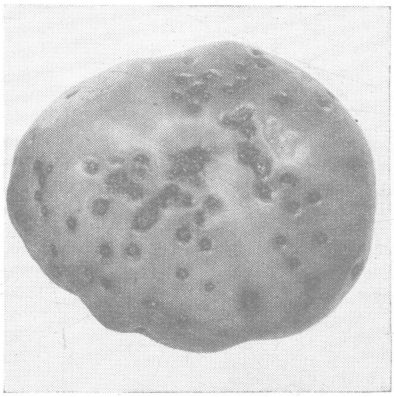


Fig. 24.—Bacterial spot on tomato fruit. (After Gardner.)

On the fruit, the disease causes at first blackened raised points, or dots, surrounded by a water-soaked border. These dots enlarge and turn black; they are slightly raised and white around the edge, where the epidermis is ruptured. Older spots may appear sunken in the center (see Fig. 24). Fruits affected with this disease are unfit for market.

It has been shown that the bacteria which cause this disease can be carried over the winter on the seed. Tests made on commercial seed, which was obtained from diseased fields, showed 1 per cent of diseased seedlings in the plant bed. The disease is carried to clean fields on infested seedlings, and is spread from plant to plant by rain splashing the bacteria, by wind blown rain, or by surface water.

When this disease is severe, more than 50 per cent of the crop may be unmarketable. During the season of 1929 this disease was prevalent in western Ohio in many fields. In 1930 it was only found in two fields and was confined to one or two plants. Undoubtedly this disease is introduced each year into the fields through the plants.

Control.—Seed disinfection and field sanitation are the only control measures known for this disease (see page 30).

Mosaic of Tomatoes

Cause Undetermined

Tomatoes are attacked by a virus disease which we call mosaic. This disease may be manifested in a number of different ways. One type of mosaic causes the tomato foliage to be fern-like, and is called fern leaf mosaic. Another type causes the leaves to be long and stringy, and is known as shoestring, or filiform, mosaic. Still a third type may cause mottling and wrinkling of the foliage, with very little stunting of the plants.

Mosaic is spread from plant to plant by careless handling, and also by sucking insects, such as aphids and leafhoppers. When plants are infected after they have set fruit very little loss is sustained. If plants are infected in the seedbed, 50 per cent or more of the crop may be lost. The only way to keep mosaic out of the plant bed is to keep all weeds down in the vicinity of the plant house, either by mulching with straw or by use of the lawn mower. Weeds which have been found to carry mosaic, include ground cherry, jimson weed, horse nettle, and black nightshade; also, cultivated plants such as pepper, petunia, and tobacco. Undoubtedly, some mosaic enters the tomato plant bed by the grower using chewing tobacco. By washing the hands thoroughly with soap and water and refraining from using tobacco while handling plants this source of mosaic can be eliminated.

Control of Tomato Diseases

1. Sterilize seed for five minutes in a 1-3000 bichloride of mercury solution. Rinse seed thoroughly after disinfecting or sow immediately.
2. Plant seed in soil which has been heated with steam to 140 degrees F. for one hour.
3. Use precautions listed under damping off to prevent seedlings from rotting off at the surface of the ground.
4. Dust or spray the plants in the seedbed every week, or ten days, with either 20-80 copper lime dust, or 2-4-50 Bordeaux mixture.
5. Keep down all weeds in the vicinity of the plant bed.
6. Do not use tobacco while working with tomato plants.
7. Do not grow pepper, or petunia plants adjacent to tomato plants.
8. Plow under completely all old tomato vines in the fall, or the following spring, before tomatoes are planted in adjoining fields.
9. Keep horse nettle, ground cherry, jimson weed, and nightshade out of the tomato field, or adjoining hedge rows.
10. Use at least a 4-year rotation.

Dusting and Spraying Tomatoes

Numerous tests have shown that there is considerable advantage in dusting or spraying tomato plants in the seedbed. When the plants first come up, two cotyledon leaves are formed. A little later, true leaves are formed, and when these first leaves appear the first application of dust or spray should be made. Then applications should be made every week to 10 days as long as the plants are in the seedbed. The last application should be made the day before the plants are set in the field.

Dusting very young plants (less than 3 inches tall) is likely to be less injurious than spraying them with Bordeaux.

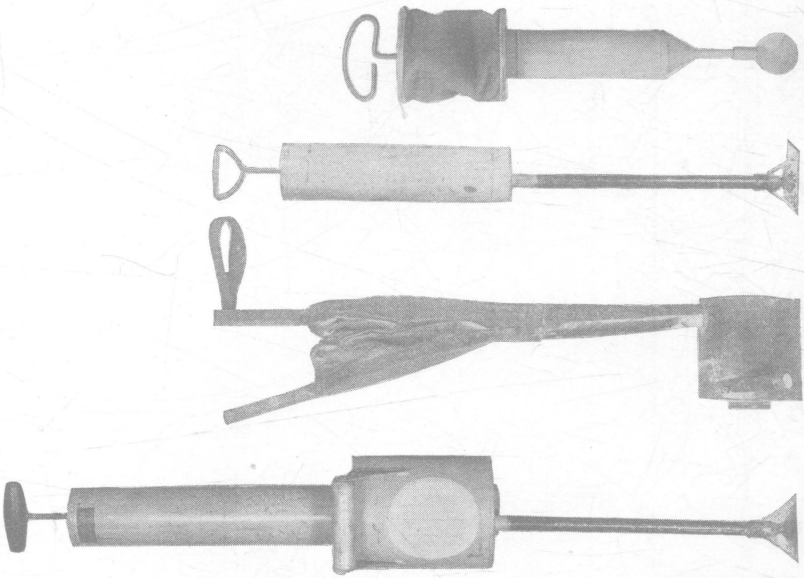


Fig. 25.—Hand dusters suitable for dusting tomato plants in the seedbed.

Dusts.—For dusting, a 20-80 copper lime dust should be used. If flea beetles are a factor, 10 per cent arsenate of lead or calcium arsenate should be added to the dust. If growers wish to mix their own dust, 12½ pounds of monohydrated copper sulfate dust should be mixed with 50 pounds of freshly hydrated, high calcium lime, and 7 pounds of arsenate of lead, or calcium arsenate.

Sprays.—For spraying, a 2-4-50 Bordeaux mixture, plus 2 pounds of the arsenical should be used.

Bulletins for Vegetable Growers

Extension Bulletins and Circulars

Extension Bulletin 86, Potato Growing in Ohio

Extension Bulletin 76, Control of Garden Insects and Diseases

Extension Bulletin 75, Mexican Bean Beetle

Extension Bulletin 103, Growing Vegetable Plants

Extension Bulletin 109, Rhubarb Culture

Extension Bulletin 110, Vegetable Forcing in Ohio

Ohio Farm Gardens

Fertilizers for Vegetable Crops

Correspondence Courses

The bulletins and circulars mentioned above and prepared especially for Ohio growers may be had by writing to the Publications Department, College of Agriculture, the Ohio State University, Columbus, Ohio.

The following bulletins may be secured from the Ohio Agricultural Experiment Station, Wooster, Ohio.

Ohio Experiment Station Bulletins

Bulletin 408, Chemical Fertilizers for Greenhouse Lettuce

Bulletin 447, Paper Mulch for the Vegetable Garden

Bulletin 399, Relation of Weather to the Dates of Planting Potatoes in Northern Ohio

Bulletin 430, The Normal Multiple Sprouting of Potatoes

Bulletin 432, Ohio Potato Diseases

Bulletin 420, Fertilizers for Early Cabbage, Tomatoes, Cucumbers, and Sweet Corn

Bulletin 433, Farmers Produce Markets in Ohio

The College of Agriculture and the Experiment Station are your institutions. Call on them when wanting help.